

COMMITTEE TR41.9 CONTRIBUTION

TITLE: Proposed Appendix to TSB-31C to Facilitate ADSL Signal Power & PSD Testing

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ABSTRACT: This contribution presents a draft proposal to revise TSB-31B with the attached Appendix F. This addition addresses an Industry need in providing a suggested test methodology for ADSL, and similar CPE, that can be registered under the terms of the Alcatel Order. The added appendix, along with other changes, would be embodied in TSB-31C.

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APPENDIX F

ADSL POWER SPECTRAL DENSITY AND SIGNAL POWER

F1. General

This appendix provides a suggested test procedure to measure both the average signal power and power spectral density (PSD) of an ADSL ATU-R, or similar CPE, against the applicable requirements specified in ANSI Standard T1.413-1998. Compliance with T1.413's signal power and PSD limitations is mandatory for CPE to be registered following a waiver and certification request made pursuant to the terms of the Alcatel Order.

F2. Conditioning the EUT to Transmit Continuously

To properly measure both the total signal power and PSD, the EUT must be conditioned to transmit at its highest signal power level and line rate without a sustained connection to companion equipment. The method of testing with a companion device is impractical for ADSL equipment since the companion ATU-C presents excessively high signal levels at frequencies at which the ATU-R's PSD mask demands very low PSD levels. The amount of attenuation required to reduce the ATU-C's signals below the upstream mask would be excessive to permit the link to come up at the maximum upstream line rate. This is because ADSL equipment automatically reduces the line rate over long loops to maintain an acceptable level of performance.

There are two possible methods to achieve the required state for the ATU-R. One method involves a test mode whereby the ATU-R's transmitter is forced to enter the show time state without going through a training sequence. Show time refers to the state where the ATU-R is transmitting a pseudo-random data pattern continuously. The other technique first involves bringing the link up over an artificial line whose characteristics effectively force the ATU-R into its maximum signal power and line rate and thus highest bandwidth state. Next, the EUT is strapped or conditioned to disable retrains so that once the show time state has been achieved, the EUT may be disconnected from the artificial line and connected to a 100 Ω measurement termination. The artificial line may be either a commercial telephone line simulator or a simple 100 Ω O-pad. In either case, the amount of through transmission attenuation must be set to maximize the EUT's transmit power and bandwidth. This is necessary as most ATU-R's utilize an adaptive transmit power scheme where power is cut back under short loop conditions. By the same token, if the line attenuation is excessive, then the link will not have sufficient margin to come up at its highest rate. The amount of line attenuation will vary from one vendor's CPE to another and even with the same CPE if the start up margin is changed.

F3. Total Signal Power – T1.413 Section 7.15

F3.1 Background

The total signal power of the ATU-R must be limited to minimize near end cross-talk (NEXT) with other DSL systems that share the same cable binder. Crosstalk is widely recognized as a form of third party harm and represents the principal impairment to many DSL systems.

F3.2 Purpose

To verify that the signal power level transmitted to the network is properly limited.

F3.3 Equipment

- (1) True rms ac voltmeter SEL#41.
- (2) 100 Ω , 1 %, non-inductive resistor.

NOTE: Refer to Section 4.4 for equipment details.

F3.4 Equipment States Subject to Test

Transmitting continuously at its highest signal power and upstream line data rate.

F3.5 Procedure

- (1) Condition the EUT to transmit at its highest upstream signal power level and line rate as described in F2.
- (2) Connect the EUT to the test circuit of Figure F3.5-1.
- (3) Measure and record the signal power level in dBm.
- (4) If the ac voltmeter has its dBm scale referenced to 600 Ω , then a correction factor of +7.8 dB must be added to the displayed reading to account for the measurement impedance of 100 Ω .

F3.6 Alternative Methods

The total signal power may also be calculated by integrating the PSD over the operating band. This task consists of measuring the PSD over the operating band using a 10 kHz resolution bandwidth at discrete frequencies with a stepped interval of 10 kHz. The individual PSD readings are then converted to power

readings by multiplying the PSD (in terms of watts/Hz) by the 10 kHz resolution bandwidth. This results in a power level for each 10 kHz window. These are then summed over the operating band to give the total power. The PSD measurement procedure is given in F4.

F3.7 Suggested Test Data

- (1) Signal Power Level.
- (2) Line Data Rate and Baud Rate if applicable.

F3.8 Comments

It is recommended that the voltmeter provide a high-impedance balanced input particularly if the EUT has intentional paths to ground.

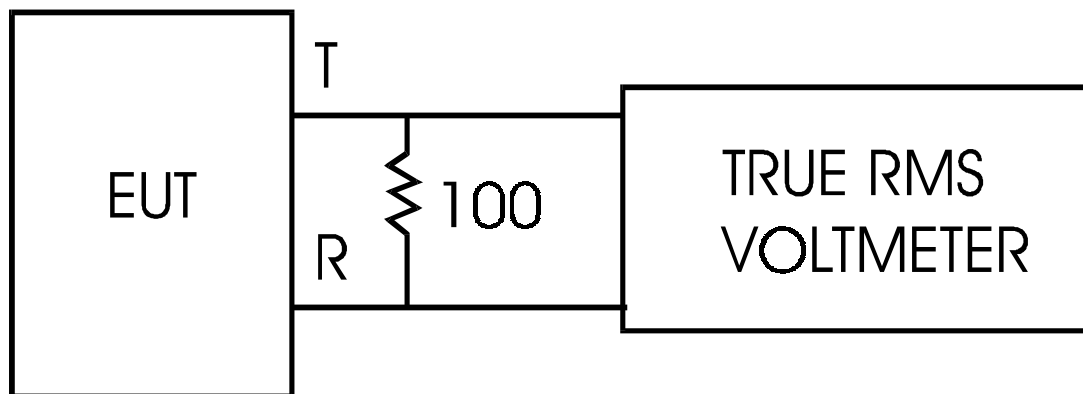


FIGURE F3.5-1. AVERAGE SIGNAL POWER

F4. POWER SPECTRAL DENSITY – T1.413 Section 7.14

F4.1 Background

As is the case for the ATU-R's total power, its PSD must be limited to minimize crosstalk. PSD is limited by the imposition of a PSD mask, which specifies a limit as a function of frequency. The mask permits a reasonable level in the operating band while restricting the ATU-R's PSD below the operating band to protect POTS and above the operating band both to minimize interference both with the downstream spectrum as well as other DSL systems potentially affected by crosstalk. The mask presents measurement challenges because it specifies such a broad range of signal levels which can't practically be made in a single sweep due to limitations in the spectrum analyzer's dynamic range. For this reason and resolution bandwidth considerations, the mask is broken into segments and either low pass or high pass filtering techniques are employed as necessary to allow the spectrum analyzer to effectively measure low PSD levels in the presence of high PSD level conditions associated with the operating band.

The procedure specifies equipment not listed in the 4.4 - Suggested Equipment List (SEL). An appended SEL has been included in F5. The SEL reference numbers continue from the last SEL # given in 4.4.

F4.2 Purpose

To verify that the PSD is below the mask.

F4.3 Equipment

- (1) Spectrum analyzer SEL#56.
- (2) 100 Ω , 1 % non-inductive resistor.
- (3) Differential amplifier with 10X passive probe set and built in LPF SEL#57.
- (4) 100:50 Ω balun transformer SEL#58.
- (5) 10 dB 50 Ω pad SEL#59
- (6) 500 kHz High Pass Filter SEL#60

F4.4 Equipment States Subject to Test

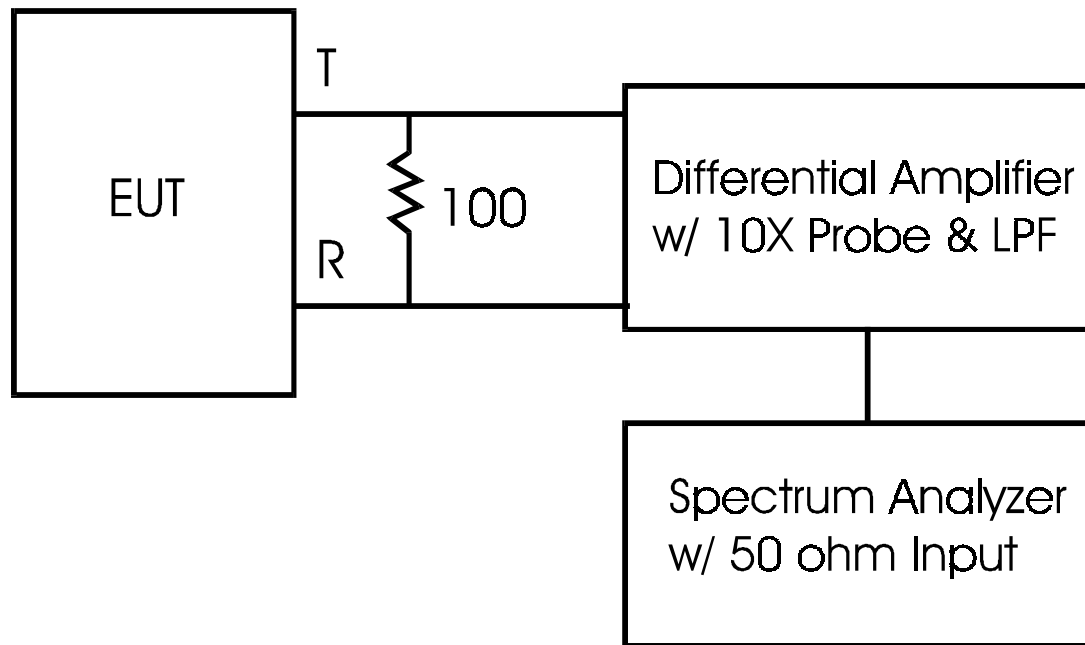
Transmitting continuously at its highest signal power and upstream line data rate.

F4.5 Procedure

The test procedure is broken down into four sections associated with making the PSD measurements in a given frequency range segment.

F4.5.1 Procedure for Segment 1

- (1) Condition the EUT to transmit at it highest upstream signal power level and line rate as described in F2.
- (2) Connect the EUT to the test circuit of Figure F4.5.1-1.
- (3) Set the differential amplifier for unity gain and a low pass cut-off frequency of 10 kHz.
- (4) Set the spectrum analyzer as follows:
 - Resolution bandwidth: 100 Hz
 - Video bandwidth: 3 Hz
 - Attenuation or range: Set for minimum without overload
 - Reference level: -40 dBm
 - dB/div: 10 dB
 - Start frequency: 200 Hz
 - Stop frequency: 4000 Hz
 - Marker Function: Noise dBm/Hz
 - Limit test: On with limit line programmed with the mask's peak limit
- (5) Measure and record the PSD over the first segment of the mask, which covers the voice frequency band.



NOTE: The PSD readings must be adjusted by a net correction factor of 17 dB derived from the 10X probe which introduces 20 dB of loss and the 100:50 ohm impedance correction factor of -3 dB.

FIGURE F4.5.1-1. PSD SETUP FOR SEGMENTS 1 & 2

F4.5.2 Procedure for Segment 2

- (1) Condition the EUT to transmit at it highest upstream signal power level and line rate as described in F2.
- (2) Connect the EUT to the test circuit of Figure F4.5.1-1.
- (3) Set the differential amplifier for unity gain with no filtering
- (4) Set the spectrum analyzer as follows:
 - Resolution bandwidth: 1 kHz
 - Video bandwidth: 30 Hz
 - Attenuation or range: Set for minimum without overload
 - Reference level: -20 dBm
 - dB/div: 10 dB
 - Start frequency: 4 kHz
 - Stop frequency: 26 kHz
 - Marker Function: Noise dBm/Hz
 - Limit test: On with limit line programmed with the mask's peak limit
- (5) Measure and record the PSD over the second segment of the mask, which covers the frequencies between the voice band and the ADSL operating band.

F4.5.3 Procedure for Segment 3

- (1) Condition the EUT to transmit at it highest upstream signal power level and line rate as described in F2.
- (2) Connect the EUT to the test circuit of Figure F4.5.3-1.
- (3) Set the spectrum analyzer as follows:
 - Resolution bandwidth: 10 kHz
 - Video bandwidth: 300 Hz
 - Attenuation or range: Set for minimum without overload
 - Reference level: -20 dBm
 - dB/div: 10 dB
 - Start frequency: 25 kHz
 - Stop frequency: 525 kHz
 - Marker Function: Noise dBm/Hz
 - Limit test: On with limit line programmed with the mask's peak limit
- (4) Measure and record the PSD over the third segment of the mask, which covers the ADSL operating band on up to 525 kHz.

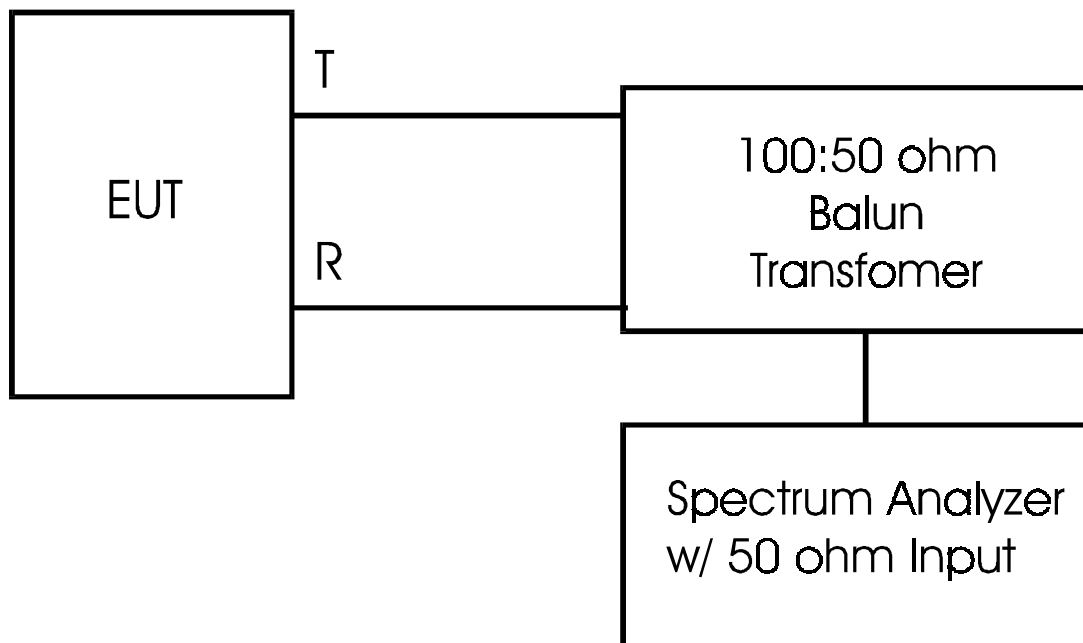
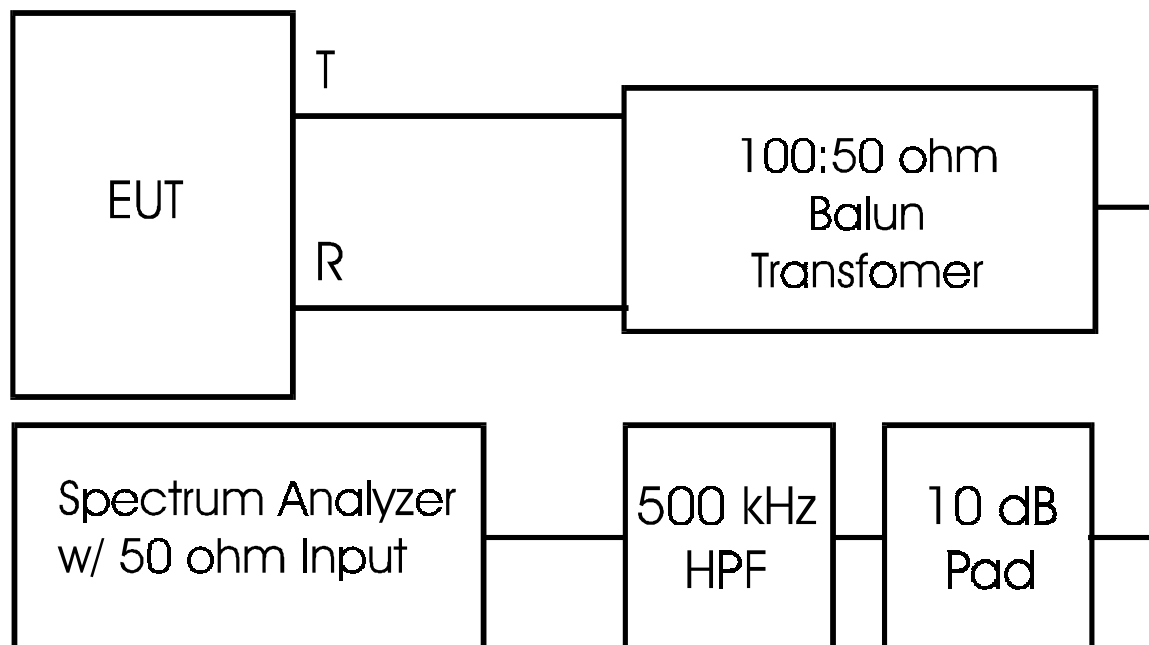


FIGURE F4.5.3-1. PSD SETUP FOR SEGMENT 3

F4.5.4 Procedure for Segment 4

- (1) Condition the EUT to transmit at it highest upstream signal power level and line rate as described in F2.
- (2) Connect the EUT to the test circuit of Figure F4.5.4-1.
- (3) Set the spectrum analyzer as follows:
 - Resolution bandwidth: 10 kHz
 - Video bandwidth: 300 Hz
 - Attenuation or range: Set for minimum without overload
 - Reference level: -70 dBm
 - dB/div: 10 dB
 - Start frequency: 525 kHz
 - Stop frequency: 11.04 MHz
 - Marker Function: Noise dBm/Hz
 - Limit test: On with limit line programmed with the mask's peak limit and above 1221 kHz the dashed line mask limit which will ensure compliance with the -50 dBm total power in a 1 MHz sliding window.
- (4) Measure and record the PSD over the fourth segment of the mask, which covers the high frequencies above the ADSL operating band.



NOTE: The 10 dB pad may be omitted if the high pass filter can withstand high input levels without introducing distortion products. The PSD readings must be adjusted to take into account losses introduced by the balun, pad and filter.

FIGURE F4.5.4-1. PSD SETUP FOR SEGMENT 4

F4.6 Alternative Methods

A balun transformer may be used instead of the differential amplifier as long as its frequency response and return loss are acceptable. Also, more than one type of balun may be used to cover the entire frequency range of interest.

If the PSD exceeds the dashed limit in the mask at any point above 1221 kHz, measurements must be made to calculate the total power in a 1 MHz sliding window. This concept was discussed in F3.6. The peak limit of -90 dBm/Hz, above 1221 kHz, must never be exceeded by any individual spectral component. However, noise may exceed the dashed line limit provided that the power integrated over a 1 MHz bandwidth is less than -50 dBm. As the procedure given in F4.5.4 suggest, the sliding window calculation is not necessary if the PSD never exceeds the dashed line. The dashed line in T1.413 Figure 32 has a noise floor of -110 dBm/Hz, which over a 1 MHz band is equivalent to -50 dBm.

F4.7 Suggested Test Data

- (1) Plots of the PSD for each segment with the limit line shown on each graph
- (2) Line Data Rate and Baud Rate if applicable.

F4.8 Comments

Care must be taken to ensure that measurement errors are kept to a minimum. Sources of error include the following:

- (1) Impedance deviations from the ideal 100 Ω termination
- (2) Differential amplifier loss or gain
- (3) Balun loss
- (4) Attenuator pad loss over the ideal loss
- (5) High pass or low pass filters' frequency response
- (6) Limited dynamic range of the differential amplifier
- (7) Limited amplitude accuracy of the spectrum analyzer

F5. Amended Suggested Equipment List (SEL)

This list itemizes the suggested requirements for test equipment needed to perform the tests in this appendix that were not listed in the primary SEL detailed in Section 4.4.

- (56) Spectrum analyzer: input impedance 50 ohms, frequency range from 20 Hz to at least 12 MHz, sensitivity of -130 dBm/Hz or better, resolution < 1 Hz, absolute amplitude accuracy ± 1.5 dB or better.
- (57) Differential amplifier with 10X passive probe set: amplifier gain 1,10, gain accuracy $\pm 1\%$, bandwidth DC to 10 MHz, output impedance 50 ohms, input resistance 1 megohm, input capacitance 20 pF, bandwidth limit filter upper cutoff frequency 10 kHz, filter response 6 dB/octave, minimum common mode rejection ratio 10000.
- (58) 100:50 Ω balun transformer: frequency range 10 kHz to 11 MHz minimum
- (59) 10 dB 50 Ω pad: frequency range DC to 11 MHz minimum
- (60) High Pass Filter: f_c 3 dB cut off frequency 500 kHz, f/f_c ratio 0.40:1, stop band attenuation -50 dBc.

Equipment Meeting the Requirements on the Suggested Equipment List

The following information has been provided as information only; to assist TR41.9 committee members in their selection of possible test equipment and accessories necessary to test ADSL equipment. Neither TIA or the contributor considers this list as an endorsement of the listed equipment or its manufacturers.

SEL #	Manufacturer	Model Number	Web Site
56	Agilent Technologies	4395A	http://www.agilent.com
57	Preamble Instruments	1820	http://www.preambleinstruments.com/
58	North Hills	0301B	http://www.northhills-sp.com/wb-balun.html
59	Agilent Technologies	8491 A	http://www.agilent.com
60	TTE, Inc.	HC5-500K-50-69B	http://www.tte.com/

Sample PSD Plots for each Segment

